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Innovative technologies in the logistics system: Digital solution implementation benefits and risks assessment

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Abstract. The research relevance is determined by the modern requirements for efficiency and speed of deliveries necessitating constant updating of logistics systems, thus successful integration of digital solutions becomes a key factor of companies' competitiveness in a dynamic business environment. The research niche of this article is the need for a consolidated assessment of benefits and risks of adopting digital technologies in logistics. The study aims to analyse the benefits and risks associated with the integration of innovative digital technologies into the logistics system to develop strategic recommendations. Analytical, functional, statistical, system analysis, deduction, synthesis and comparison methods were applied.

The key aspects of integrating innovative digital technologies into the logistics system were examined to test the hypothesis that net performance gains depend on aligned technology selection, staff training and cybersecurity controls. Systematic assessment of the benefits that companies can achieve when implementing innovative technologies such as automated warehouse management systems, real-time delivery monitoring, big data analytics and blockchain technologies was emphasised. Potential risks were highlighted as well, including the financial costs of implementing new technologies, difficulties in training staff and possible technical failures. The study also emphasises the importance of adapting logistics systems to modern market requirements to ensure the sustainability of enterprises in a rapidly changing business environment. The conclusions provide strategic recommendations for companies seeking to optimise their logistics processes. The practical relevance of this study is to provide specific strategic recommendations for companies in the field of logistics, ensuring an informed choice of innovative digital technologies.
Keywords: automation and process optimisation, supply chain monitoring, big data analytics, blockchain, cybersecurity

Introduction

In the era of innovation and digital progress, the issue of effective management of logistics processes has become extremely relevant for modern enterprises. The current competitive environment requires companies to constantly update and improve their logistics systems, which in turn contributes to improving their competitiveness and meeting growing consumer expectations. The integration of innovative digital technologies in the logistics system offers significant opportunities to optimise processes, speed up deliveries, reduce costs, and improve overall efficiency. However, despite these potential benefits, businesses also face several complex issues.

This topic involves an analysis of the benefits and risks associated with implementing digital solutions in logistics. The main challenges include high financial costs for implementation and staff training, difficulties in selecting the best technology for a particular business, and the need to overcome technical and organisational barriers. These aspects require careful analyses and sound strategies to successfully integrate digital innovations into logistics operations. In this context, conducting a study to assess the benefits and risks of integrating digital technologies into the logistics system is an urgent task with a broad prospective impact on business development in today's dynamic economic environment.

A. Hajiyeva (2020), in an analysis of the impact of digital technologies on logistics processes, determined that the implementation of automated management systems significantly reduces time and costs in the supply chain. Highlighting significant efficiency improvements, the study raises the important question of how these technologies can be a key enabler for optimising business processes in logistics. Focusing on real-time supply chain monitoring systems, A. Gulıyev (2021) presented results that emphasised the superiority of such technologies. That study demonstrates that through real-time monitoring systems, companies can not only predict delivery

times with high accuracy but also minimise downtime in the supply chain, which has a direct impact on operational efficiency.

After analysing the experiences of companies that have successfully applied blockchain technology in logistics, J. Nurullayev et al. (2022) determined that blockchain significantly increases the transparency and reliability of the supply chain. The study results signify a revolution in the smooth flow of information, emphasising the role of blockchain technology in creating reliable digital reports in the supply chain. N. Ismayil and Ö. Karagulle (2023) developed a methodology to assess the financial cost and cost-effectiveness of implementing digital solutions in logistics. Their study provides specific tools for business analyses and emphasises the importance for enterprises to address financial constraints for informed decision--making. A. Guliyeva and U. Rzayeva (2022) addressed the problems of staff training when introducing innovative technologies in the logistics system. They highlight the challenges of this process and offer specific strategies for effective adaptation of staff to new digital tools, accounting for the individual characteristics of training and the degree of staff involvement in the change process.

The authors' studies show that the adoption of digital technologies, such as automated management systems and monitoring technologies using blockchain and financial costing systems, contributes to significant improvements in efficiency, transparency, and operational flexibility in logistics systems. However, the implementation of digital technologies in logistics systems, including staff adaptation and training, change management, and evaluation of long-term effects, was not addressed sufficiently.

The research problem addressed in this article is the lack of a consolidated, decision-oriented assessment enabling enterprises to balance the benefits and risks of implementing digital solutions in logistics systems. The study addresses the following research questions: (RQ1) What are the key benefits and risks associated with adopting digital technologies in logistics? (RQ2) What implementation conditions help enterprises realise measurable performance gains while mitigating organisational and cybersecurity risks?

The research hypothesis assumes that the net benefits of digital adoption are maximised when technology selection is aligned with process needs and supported by staff training and cybersecurity controls. The scope of the considerations covers enterprise-level logistics processes and focuses on automation, real-time monitoring, big data analytics and blockchain technologies.

The study aims to analyse aspects of digital technology adoption in logistics systems to develop a comprehensive approach that will ensure more successful and sustainable integration of innovation into the logistics activities of enterprises.

Materials and Methods

The materials used in the research process included information provided by the State Statistical Committee of the Republic of Azerbaijan (2024), which provided access to official statistical data on the logistics sector. Official documents from industry agencies and leading companies in the logistics sector were used to include expert opinions and practical experience of key market players. The use of digital technologies in logistics systems in countries such as Germany, the USA, China, Japan, Korea, Azerbaijan, Turkey, and Ukraine was investigated. The research findings included data from global logistics performance rankings such as the Logistics Performance Index (LPI) (2024), which provided context and comparative analyses between different countries and regions.

The analysis in the context of the study of digitalisation of the logistics system was used to deconstruct complex tasks into simpler components for detailed analysis. The analytical analysis of the implementation process of the supply chain monitoring system was used to identify the stages, such as software selection, staff training, testing, and step-by-step scaling. The functional method was used to highlight the role of each component of the logistics system and identify the relationships between them. This approach also provided an in-depth understanding of how changes in one part of the system would affect the rest. The functional study of blockchain technology in logistics highlighted key functions such as transparency, process automation, and enhanced data security.

The statistical method was used to conduct an in-depth study of the data, revealing key trends and patterns in the development of logistics systems. It determined the trend of transport revenues in the transport sector and investments in the transport sector in Azerbaijan, providing an understanding of the main factors affecting the economic condition of logistics systems, as well as an assessment of their contribution to the total turnover of funds and investments in the sector. The system analysis was used to examine the logistics system as a whole, identifying the interrelationships between its components to understand the impact of external factors. All aspects of the study were covered, and the impact of digitalisation on the entire supply chain was examined.

The deduction was used to introduce general patterns from theoretical principles and to highlight common trends in the context of the implementation of digital solutions in logistics. The synthesis combined different elements and ideas into a holistic understanding. This method identified a comprehensive solution covering all aspects of the study, including technical, social, and economic factors. The comparison was used to investigate similarities and differences between different solution options, determining the best solution for a particular context, for example, by comparing different supply chain monitoring systems in terms of their functionality, cost, and complexity.

In summary, these techniques were successfully employed to develop a fundamental research framework that not only analysed the impact of digital technologies on logistics systems but also provided recommendations for optimal implementation, including the variety of factors affecting the success of integration.

Results

Modern logistics systems are undergoing a dynamic transformation under the influence of innovation and technological development. The introduction of new technologies brings changes in traditional management methods and opens new horizons for improving the efficiency of supply chains. This study will examine the key aspects of the role of innovation in logistics systems. One of the most important aspects of innovation's role in logistics is the automation and optimisation of processes. The introduction of robotic assembly systems, automated warehouse management systems, and autonomous vehicles significantly reduces time delays and costs in logistics operations. Such technology not only increases efficiency but also reduces the risks of human error by providing more accurate and faster processes (Chung, 2021). The adoption of digital technologies such as the Internet of Things (IoT), blockchain, and artificial intelligence is leading to the digital transformation of logistics systems (Górska, Daroń, 2024). The creation of smart logistics systems that can track shipments, predict demand, and respond to changes in real-time brings flexibility and responsiveness to supply chain management (Yang et al., 2021).

Innovation also improves transparency and traceability in supply chains. Adopting technologies that enable real-time tracking of cargo location, monitoring the status of goods, and managing information improves the reliability and manageability of supply chains. Such visibility is essential for rapid decision-making and reducing delivery time (Syed et al., 2022; Liu et al., 2024). Security of logistics operations is a priority, while innovation significantly contributes to the sphere. Employment of biometrics technologies, video surveillance systems, and machine learning algorithms increases protection against loss, theft, and other risks (Zyhrii et al., 2023; Hajiyev et al., 2025). Such innovations improve the overall security of the entire logistics system. Innovative technologies provide logistics systems with greater flexibility and adaptability to changes in the business environment (Zhan et al., 2022). Improved forecasting systems, analytics, and optimisation techniques make it easier to adapt to changes in demand, market conditions, and the competitive environment.

In a world where logistics play a key role in ensuring supply chain efficiency and meeting consumer demands, countries around the world are actively adopting innovative technologies to optimise their logistics systems. For instance, Germany, with its tradition in manufacturing and emphasis on quality, is a technological leader in logistics. The country is actively adopting IoT technologies to monitor and manage

vehicles and inventory in warehouses (Bartsch, Winkler, 2020). The United States emphasises the research and development of new technologies for logistics. Drones and autonomous vehicles are becoming commonplace for freight delivery, and data analytics and artificial intelligence are being used to forecast demand and optimise logistics processes (Gutelius, Theodore, 2019). China is a global leader in e-commerce and digital technology. The use of artificial intelligence and big data in supply chains improves efficiency and responsiveness. Blockchain technologies are being used to create more transparent and reliable logistics systems (Amling, Daugherty, 2020). Japan is focusing on the development of robotic systems and automation technologies in logistics. Robots are used to sort goods in warehouses, and smart vehicle systems ensure efficient delivery. This country is actively exploring the possibilities of autonomous vehicles (Jingxian, 2021). Singapore is a pioneer in creating smart cities and ports. The use of Internet of Things technology to monitor and manage transport systems and the introduction of autonomous vehicles make logistics more efficient and transparent.

The diverse experiences of different countries in logistics innovation emphasise the importance of the strategic adoption of digital technologies to ensure the competitiveness and efficiency of logistics systems in today's global marketplace. The diverse experiences of various countries in adopting digital technologies present both benefits and risks to logistics. Benefits include increased efficiency, optimised operations, improved forecasting accuracy, and meeting rising consumer expectations. However, digital integration also brings risks, such as cyberattacks, potential data privacy breaches, and high costs of implementing new systems (Trofymenko et al., 2024). Countries that are actively adopting drones and autonomous vehicles face security and regulatory issues that could slow down the integration process.

With the emphasis on the use of artificial intelligence and big data, most countries face privacy challenges and ethical issues related to the use of personal information (Zaplatynskyi et al., 2024). With the use of robotic solutions, countries may face challenges in staff training and potential resistance from workers. In the pursuit of smart cities and drone technology, there may be challenges in data management, cybersecurity, and the need to create the right legal and regulatory environment. Thus, assessing the benefits and risks of integrating digital technologies becomes an integral part of the strategic development of logistics systems globally (Pan et al., 2021).

Digital technologies have become a key factor in optimising logistics systems in various countries, including Azerbaijan, Turkey, and Ukraine (Bulatov et al., 2020). Azerbaijan's logistics sector has seen successful implementation of digital technologies, especially in transport and customs processes. One example is the use of an electronic cargo clearance system at borders. This innovative system speeds up the customs clearance and cargo management process, enabling more efficient transport flows. Electronic clearance reduces bureaucratic barriers, minimises time delays, and increases the transparency of logistics operations, facilitating a more efficient movement of goods across borders (Aliyev, 2023).

Turkey is actively implementing digital solutions in e-commerce and logistics. The country is focusing on integrated logistics platforms that optimise warehousing processes, inventory management, and cargo tracking. An example of successful implementation of digital technologies is the e-commerce platform Trendyol (Turkish marketplace Trendyol…, 2024), which has implemented intelligent inventory management systems to improve logistics processes. Such management systems bring significant changes to logistics operations, increasing efficiency and reducing time costs.

Ukraine is witnessing the introduction of smart technologies in transport and warehouses. Digital cargo tracking and management systems improve transparency and control in logistics processes. For example, Nova Post (2024) has implemented an online shipment tracking system, which has made it much easier for customers to track parcels and optimise delivery. Automated warehouses equipped with state-of-the-art technology enable efficient inventory management and reduce operating costs (Kiurchev et al., 2023).

These examples show that countries in Eastern Europe and the South Caucasus, including Ukraine, Turkey, and Azerbaijan, are striving for digital transformation of logistics systems. Digital innovation not only improves the efficiency and transparency of logistics processes but also makes countries more competitive in the global market. It is necessary to note that digitalisation also has its challenges, such as the need to train staff, ensure cybersecurity, and develop appropriate regulation. Table 1 presents the LPI for different countries.

Table 1. LPI index country rating, 2023

Rank	**Countries**	**Index**
1	Singapore	4.3
2	Finland	4.2
3	Denmark	4.1
4	Germany	4.1
5	Netherlands	4.1
6	Switzerland	4.1
7	Austria	4
8	Belgium	4
9	Canada	4
10	Hong Kong	4
…	…	…
38	Turkey	3.4
79	Ukraine	2.7
79	Georgia	2.7

Source: Compiled by the authors based on the Logistics Performance Index (2024)

Among the leaders of the ranking are highly developed economies such as Singapore, Finland, and Germany. Their position reflects their high-quality logistics infrastructure, efficient transport systems, and high level of organisation in customs processes. Turkey, Ukraine, and Georgia rank lower in the rankings. The low scores can be attributed to various factors, such as imperfect infrastructure, difficulties in customs procedures, and peculiarities of the logistics system. Nevertheless, these countries have the potential to improve their performance through the introduction of modern technologies and structural reforms in the logistics sector.

It is worth noting that Azerbaijan data are not included in the assessment of the LPI. The last time this indicator for Azerbaijan was calculated, in 2014, it was 2.5, with 125th place in the world ranking. However, at this point, with the Alat Free Economic Zone (AFEZ) and the Ipek Yolu road, the country would rank a certain place in the LPI. The Zangezur corridor can also play a key role in the development of the country's logistics system. This corridor is a major transport project, actively supported by Azerbaijan, aimed at creating transport links through the territory of Armenia with a length of about 40 kilometres. The main objective is to establish strong transport links between the western regions of Azerbaijan and the Nakhchivan Autonomous Republic (NAR). In the Washington Declaration signed on 8 August 2025, the planned transit route was presented as a project named the Trump Route for International Peace and Prosperity (TRIPP). Azerbaijan and Turkey regularly support this strategic corridor, but Armenia consistently opposes it. According to calculations by the Centre for Analysis of Economic Reforms and Communications of Azerbaijan, unblocking transport links between the territory of Azerbaijan and NAR could increase exports by 710 million USD. In this regard, Azerbaijan will be able to save about 10 million USD on subsidising air flights from Baku to Nakhchivan. In addition, the opening of a railway connection could facilitate gas supplies (Jabbarov et al., 2022). To assess the logistics system in Azerbaijan, Table 2 was compiled to show the transport revenues in the transport sector.

Table 2. Revenues from transport in the transport sector of Azerbaijan, million AZN

	2018	**2019**	**2020**	**2021**	**2022**	**2023**
Railway	270.8	299.8	274.8	284.7	398.9	411.1
Maritime	170.6	180.5	168.9	178.6	248.8	262.3
Airborne	2066.9	2396.4	3035.2	3875.4	4904.8	5101.5
Pipelines	2272.5	2292	2323.7	3049.5	3567.1	4112.2
Oil pipeline	1539.7	1313.3	1127	1197.6	1238.9	1321.2
Natural gas pipeline	732.8	978.8	1196.7	1851.9	2328.2	2561.1
Automotive	1396.9	1844.2	1181.9	1274.6	1692.6	1823.7
Metro	54.2	689	21.6	26.2	60.7	65.5
Overall	6231.9	7081.7	7006.4	8688.9	10873.1	15649.6

Source: compiled by the authors based on the State Statistical Committee of the Republic of Azerbaijan (2024).

Total revenues have increased significantly over the years, reaching AZN 15.6 billion in 2023. At the same time, air and pipeline transport are the most profitable segments, significantly increasing their share in total revenues. Table 3 presents investments in the transport sector in Azerbaijan.

Table 3. Investments in the transport sector of Azerbaijan, million AZN

	2018	**2019**	**2020**	**2021**
Land and pipeline transport operation	305.2	377.5	389.8	166.9
Railway transport	7.1	1.2	1.2	0.4
Other automotive transport	129.8	235.8	266.8	109.2
Pipelines	168.3	140.5	121.8	57.3
Maritime transport	115.4	98.4	53.3	40.3
Airborne transport	39.4	33.7	109.7	147.1
Warehouse and utility transport	1462.8	1679.6	1538.8	2503
Overall	1922.8	2189.2	2091.6	2857.3

Source: Compiled by the authors based on the State Statistical Committee of the Republic of Azerbaijan (2024)

Total investments in the transport sector have been increasing over the years and reached AZN 2.857 billion in 2021. Most investments are in warehouse operations and auxiliary transport, indicating a strategic focus on this segment. Germany has historically been a leader in digital logistics, propelled by its robust industrial foundation and cohesive supply chain networks. A significant advancement is the establishment of the Digital Transport and Logistics Forum, which aims to develop interoperable digital platforms and enhance standardised logistics data interchange (European Commission, 2025). German logistics firms often implement IoT technologies to monitor inventory and vehicle conditions in real time, facilitating predictive maintenance and enhanced fleet management. Blockchain technology is being tested for customs documents and smart contracts to enhance cross-border efficiency (Bartsch, Winkler, 2020). These initiatives demonstrate a systematic approach to digitisation that integrates public policy with sophisticated technological implementation.

The United States possesses a varied and innovation-orientated logistics ecosystem, wherein digital technologies are pivotal in warehouse automation, last-mile delivery, and freight routing. Prominent logistics companies like FedEx and UPS have adopted machine learning algorithms for real-time delivery optimisation, while Amazon has innovated with autonomous mobility robots in its fulfilment hubs (Gutelius, Theodore, 2019). Simultaneously, start-ups and technology companies facilitate the growth of drone-based delivery systems and artificial intelligence-driven supply chain analytics. The National Freight Strategic Plan illustrates the importance of data integration, resilience, and cybersecurity within logistics infrastructure (U.S.

Department of Transportation, 2025). These advancements exemplify the United States' robust focus on private sector innovation, bolstered by governmental frameworks designed to enhance digital infrastructure and competitiveness.

China excels at digitising logistics, notably through the use of big data analytics, artificial intelligence, and blockchain in its supply chains. China has established highly efficient smart logistics centres in cities such as Shenzhen and Hangzhou, bolstered by state-led projects like Made in China 2025 and the Digital Silk Road (Muratbekova, 2021; Putra et al., 2024). Prominent e-commerce companies, like Alibaba and JD.com, employ advanced warehousing systems that utilise robotics and real-time inventory surveillance. Blockchain applications have been implemented in customs procedures to improve traceability and confidence in cross-border logistics (Amling, Daugherty, 2020). The swift advancement of digital transformation in China's logistics industry illustrates the interaction between governmental planning and private-sector implementation, establishing the country as a significant benchmark in worldwide digital logistics innovation.

Japan uses its technological proficiency and demographic obstacles to promote innovation in logistics automation and robotics. Due to a declining workforce, Japanese logistics companies are progressively investing in automated warehouses, robotic picking systems, and autonomous delivery vehicles. Prominent examples include Yamato Transport's implementation of AI-driven route optimisation and Panasonic's advancement of intelligent warehousing systems (Jingxian, 2021). The Ministry of Land, Infrastructure, Transport, and Tourism of Japan has advocated for digital platforms facilitating goods matching and real-time cargo monitoring. These solutions seek to enhance efficiency while addressing sustainability and urban congestion challenges. Japan's experience illustrates the value of technological integration in overcoming structural limitations through intelligent logistics systems.

As logistics systems grow more digital and dependent on networked platforms, cybersecurity has become a vital element of sustainable logistics operations (Parczewski et al., 2024). In contrast to generic IT security, logistics-specific cybersecurity must include the intricacies of supply chains, the immediacy of transport data, and the convergence of operational technologies (OT) with information technologies (IT). Logistics firms encounter increased hazards associated with cargo tracking technologies, warehouse automation, and blockchain transaction records (Kipane et al., 2023). This has led to the establishment of numerous national and international frameworks. Major logistics providers in the United States have implemented the National Institute of Standards and Technology Cybersecurity Framework to enhance the security of fleet telemetry and inventory management systems. Directive (EU) 2022/2555 of the European Parliament and of the Council "On measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive)" (2022) establishes cybersecurity mandates for logistics

and transport operators, particularly those designated as vital infrastructure. National digital plans in South Korea and Japan mandate logistics companies to establish endpoint detection and real-time threat response systems, especially inside smart port settings.

Additionally, standards for logistics, like ISO/IEC 27019:2024 "Information security, cybersecurity and privacy protection – Information security controls for the energy utility industry" (2024) (which deals with control systems in transportation) and ISO 28000:2022 "Security and resilience – Security management systems – Requirements" (2022) (which focuses on managing supply chain security), offer organised ways to assess risks, control access, and respond to incidents. Despite these advancements, small and medium-sized firms (SMEs) frequently lack the requisite resources or technical expertise to comprehensively deploy such frameworks, hence heightening their susceptibility to ransomware, phishing attempts, and operational interruptions. An effective cybersecurity plan in logistics must be multi-layered, incorporating technological safeguards, regulatory compliance, staff training, and sector-specific risk modelling (Pac, 2024). In this environment, cybersecurity is not solely an IT issue but a strategic necessity for operational continuity and confidence in digitally transformed logistics networks.

Digitalisation in logistics improves operational efficiency and significantly supports sustainable development goals (Destek et al., 2024). Digital tools facilitate environmental efficiency through emission reduction, resource optimisation, and waste minimisation, concurrently yielding economic benefits (Khan et al., 2025). Intelligent routing systems, for example, save fuel consumption by optimising delivery routes, while predictive inventory solutions minimise overstocking and its related environmental impact (Kopishynska, Weiyue, 2024). In China, digital goods platforms facilitate load consolidation and multimodal logistics, reducing last-mile emissions. Countries, such as Germany and Japan, have implemented AI-driven planning systems to reduce idle hours and enhance transport efficiency, thereby aligning logistics operations with national decarbonisation objectives. Sustainability indicators inform these instances, demonstrating how digital transformation can simultaneously enhance competitiveness and promote environmental responsibility.

The success of such change is contingent upon the regulatory settings governing logistics systems. Although numerous governments have established national strategies to promote digital innovation, their formulation and execution differ. Germany's Digital Strategy 2025 and Mobility Data Space establish mechanisms for interoperable data transmission while ensuring stringent privacy compliance (Federal Ministry for Economic Affairs and Energy, 2025; National Academy of Science and Engineering, 2024). Conversely, China implements stringent data retention and cross--border cyber control regulations. Turkey's e-logistics programmes, overseen by the Digital Transformation Office, exhibit inconsistent implementation across regions, while Ukraine's National Transport Strategy emphasises digital infrastructure but

lacks comprehensive regulation in the private sector (Dmitriev, Plastunyak, 2020). The discrepancies in legislative maturity hinder the scalability and integration of digital logistics technology, highlighting the necessity for unified legal frameworks (Sopilko, Rapatska, 2023).

International regulatory mechanisms are influencing the digitisation of logistics outside national domains (Jablonskis et al., 2018). The WTO Trade Facilitation Agreement advocates for electronic customs documentation and risk-based inspection frameworks, facilitating digital border crossing in nations such as Azerbaijan and Turkey. Germany and Ukraine have embraced the UNECE e-CMR protocol, facilitating electronic consignment paperwork that enhances transparency and mitigates delays. Technical standards like ISO 28000 (2022) and ISO/IEC 19845:2015 "Information technology – Universal business language" (2015) (electronic business documentation) enhance interoperability among national systems. Collectively, these tools provide a regulatory framework that fosters confidence, coordination, and data consistency in international logistics networks.

Global leaders have embraced numerous technical capabilities of artificial intelligence and machine learning, but their adoption among SMEs remains constrained. The large amount of data and computing power needed to use AI for forecasting, inventory management, and routing creates this gap. The prevalence of major entities like Amazon, JD.com, and DHL in implementing these systems highlights the unequal allocation of digital capabilities throughout the industry. Consequently, improving digital inclusion for SMEs is an essential policy objective to prevent exacerbating competitive disparities.

Digital changes are redefining the logistics labour market. Automation has supplanted low-skilled positions, especially in warehouses, while simultaneously creating a demand for experts in systems administration, cybersecurity, and data analytics (Matskiv et al., 2025). Countries like Germany and South Korea have implemented sector-specific retraining programmes associated with Industry 4.0, but Azerbaijan and Ukraine still lack such national initiatives. This gap threatens to intensify labour market inequalities and hinder workforce adaptation, underscoring the necessity of targeted upskilling in the context of sustainable logistics modernisation.

Simultaneously, ethical issues are gaining prominence as logistical operations become more reliant on data. The use of AI to monitor employee performance prompts concerns around surveillance and workplace stress, while biometric systems implemented in logistics centres, particularly in China, present issues relating to data privacy and informed consent. Furthermore, algorithmic decision-making systems, if inadequately vetted or trained based on biassed data, may reproduce or exacerbate disparities in processes, such as customs clearance or product prioritisation. Mitigating these dangers necessitates clear algorithmic design, accountable data management, and stringent ethical supervision.

Organisational opposition constitutes a substantial obstacle to digital adoption. In Turkey and Ukraine, the hesitation to use blockchain and integrated IT platforms frequently arises from financial apprehensions, ambiguity regarding return on investment, and reliance on outdated systems. Family-owned and locally established enterprises exhibit notable reluctance, lacking the necessary change management frameworks or digital proficiency. Effective transformation in these situations requires leadership dedication, incremental implementation methodologies, and continuous staff involvement to foster confidence and capability.

The fundamental disparity between SMEs and large enterprises in logistics is increasingly evident. Although corporations have the financial resources and infrastructure to implement sophisticated systems, several SMEs, especially in Azerbaijan and Ukraine, still depend on paper records or basic digital tools. Addressing this disparity necessitates the implementation of policies that enhance access to cloud platforms, promote digital advancements, and cultivate public-private collaborations to ensure fair involvement in contemporary logistics ecosystems.

Recommendations for the optimal integration of modern technologies into logistics systems have been developed, which can provide a strategic foundation for companies seeking to optimise their processes. Conduct a thorough analysis of the current needs and strategic goals of the logistics system before implementing digital technologies. The process includes identifying weaknesses in the supply chain, as well as determining which specific challenges can be addressed using digital solutions. A company focused on global trade may point out that it requires greater visibility and traceability of shipments to improve overall efficiency.

Integrating multiple technologies can be more effective. For example, combining monitoring, blockchain, and analytics can create a harmonised management and control system. A company that chooses to integrate real-time monitoring, blockchain, and analytics can achieve maximum transparency in the supply chain (Artyukh et al., 2023). The willingness of staff to utilise new technologies is a key success factor. Training should include technical aspects and awareness of the impact on business processes. Systematic training programmes will help staff to master new tools, ensuring smooth operations during the digital transition.

As digitalisation increases, so does the level of cybersecurity threats (Arstanbekov et al., 2024). The use of modern data protection technologies and cybersecurity training for employees is becoming an integral part of the integration. For example, implementing effective encryption and regular staff training can reduce the risk of cyberattacks and data breaches. Given the complexity of logistics systems, the introduction of new technologies should blend seamlessly with existing systems, preventing duplication and ensuring interoperability (Zavadska, Oksenyuk, 2024). A company integrating digital technologies should consider existing platforms to avoid conflicts and maintain stability.

Once implemented, performance should be evaluated regularly using key performance indicators. This will help to identify improvements and adapt the strategy to changes in the business environment. Regular audits and monitoring will facilitate the continuous improvement of logistics processes and adaptation to new market challenges. Effective integration of digital technologies into the logistics system requires a comprehensive and thoughtful approach that considers the company's specific characteristics and strategic goals.

Considering Azerbaijan's strategic position and its growing digital logistics initiatives, specific measures could enhance the country's evolution into a regional logistics centre. To bridge the digital divide between large firms and SMEs, Azerbaijan should enhance subsidised access to cloud-based logistics platforms and digital training programmes, particularly for semi-formal and regionally integrated entities. Furthermore, improving regulatory coherence is crucial. Adopting international standards like the UNECE e-CMR protocol and achieving full compliance with ISO 28000 and ISO/IEC 19845 may enhance interoperability with EU and Central Asian markets. Azerbaijan ought to establish a national logistics upskilling initiative aligned with its digital economy goal, targeting deficiencies in cybersecurity, AI-driven logistics management, and intelligent warehouse operations. Ultimately, advocating for public-private collaborations in green logistics innovation, such as route optimisation and multimodal freight consolidation, would harmonise economic modernisation with the country's sustainability and emissions reduction commitments.

The results of this study underscore the importance of innovation and digital transformation in modern logistics systems. By analysing key aspects of the impact of innovation, several important trends and challenges can be identified. Automation and process optimisation, especially the introduction of robotic systems and autonomous vehicles, have a significant impact on the efficiency of logistics operations (Bulatov et al., 2024). Reducing time delays and costs while maintaining a high level of accuracy promises significant benefits for companies seeking to improve their competitiveness. Digital transformation, including the use of the Internet of Things, blockchain and artificial intelligence technologies, is becoming a key driver for smart logistics systems. This provides the ability to track shipments in real-time, predict demand, and respond quickly to changes in market conditions. Technologies that enable real-time tracking of shipments, monitoring of goods condition, and information management are facilitating more responsible management of logistics processes. The introduction of biometric technologies and machine learning algorithms increases protection against risks such as theft and losses (Badovskis et al., 2017).

However, despite the clear benefits, innovation also presents several challenges and risks. Cybersecurity is becoming increasingly critical due to the proliferation of digital technologies. Regulation and staff training are also being pushed forward

as key success factors. Looking at global experience, advanced economies such as Germany, the US, and Singapore are actively implementing innovative technologies in logistics systems, which confirms their leadership in global logistics performance rankings. However, the low positions of countries in the region, such as Turkey, Ukraine, and Azerbaijan, in these rankings indicate the need for additional efforts in digital transformation to improve their logistics performance. Thus, the introduction of innovation and digital technologies into logistics systems offers significant prospects for improving efficiency, transparency, and security. However, successful implementation requires in-depth needs analysis, staff training, effective cybersecurity management, and integration of existing systems. All things considered, gaining a competitive edge in the modern world requires a strategic approach to digital transformation in logistics.

Discussion

S. Winkelhaus and E.H. Grosse (2020) presented an in-depth analysis of the impact of innovation on modern logistics systems. Automation and process optimisation are the two main elements contributing to the efficiency of logistics operations. One of the important conclusions of the authors was to highlight the role of digital technologies such as IoT, blockchain, and artificial intelligence in establishing the digital transformation of logistics systems. The authors stressed that the creation of intelligent logistics systems that can track shipments in real-time, forecast demand, and respond to changes brings flexibility and responsiveness to supply chain management. It is also worth noting that the authors, similar to the study, did not limit themselves to looking only at the positive aspects of logistics innovation. They emphasised the technological challenges that companies face when implementing modern solutions. This is an important direction, as it emphasises the need to address technological challenges and ensure readiness to overcome them in the process of implementing innovations in logistics systems.

A. Lagorio et al. (2022) analysed the application of digital technologies in logistics in depth, focusing on the key aspects they bring to modern logistics systems. One of the authors' key refinements was to highlight transparency and security in supply chains as critical factors that innovation can deliver. Creating transparent systems for real-time tracking of shipments and managing information on the status of goods contributes to more secure and manageable supply chains (Mamasydykov et al., 2019). This, in turn, is a critical aspect for faster decision-making and shorter delivery times. Furthermore, the use of biometric technologies, video surveillance systems, and machine learning algorithms in the context of protecting against loss, theft, and other risks, according to the author, improves the overall security of the entire logistics system. Compared to the present study, the authors' results

complement and expand the authors' understanding of the impact of digital technologies on logistics systems. Both studies confirm that process automation and optimisation, including the use of robots, warehouse management systems, and autonomous vehicles, significantly reduce delays and costs in logistics operations.

M. Cichosz et al. (2020) analysed the impact of digital transformations on the logistics industry. The study highlighted several key aspects that can have a significant impact on logistics companies. New technologies can improve logistics operations' efficiency and optimise the entire supply chain cycle. This includes automation, improved real-time monitoring, and demand forecasting. Such innovations promise significant improvements in operational efficiency. The authors drew attention to the need for staff training. The effective training of employees to use new technologies is crucial for the successful implementation of digital innovation (Matskiv et al., 2025). The authors' results, like the present study, indicate the impact of digital transformation on transparency and security in the supply chain. However, the authors placed more emphasis on employee training and cybersecurity management as important elements in the successful implementation of digital innovation in logistics. This provides additional depth to the study by drawing attention to issues related to human factors and cybersecurity.

Ş.Ö. Ekici et al. (2019) addressed the innovative practices in logistics undertaken by different countries. The researchers reached an important conclusion that countries with highly developed economies demonstrate successful use of digital technologies in logistics. Developed economies possess not only advanced technological solutions but also the ability to effectively integrate them into logistics processes. Countries have both the financial capacity to implement new technologies and the infrastructure, educated workforce, and more favourable conditions to successfully adopt digital solutions. This, in turn, provides them with a competitive advantage in global rankings of logistics efficiency. The authors' thesis directly correlates with the present study, which also emphasises the impact of digital transformation on logistics systems efficiency. The authors identify successful examples of countries where innovations in logistics have had a noticeable positive effect on the economy. This approach complements the results by enhancing the understanding of how digital technologies affect logistics systems in different contexts.

R. Giusti et al. (2019) also highlighted the significant technological challenges that companies face when innovating in logistics. Researchers highlighted that, along with the positive aspects of automation and process optimisation, there are technological challenges, such as cybersecurity. As companies innovate to increase efficiency, they also face rising technological risks. Data security issues, threats of cyberattacks, and potential leaks of sensitive information become significant aspects that need to be considered in innovation strategies. It is also worth considering that in addition to focusing on cybersecurity at a technical level, it is important to ensure that staff are cybersecurity literate. Effective staff training is becoming a key factor in

preventing insider threats. Companies can benefit from working with cybersecurity professionals to develop and implement effective security strategies.

A comparison of the authors' findings with the study confirms the importance of digital transformation in logistics, including automation, transparency, staff training, and cybersecurity management. The additional focus on cybersecurity emphasises the need for an integrated approach to innovation that addresses technological challenges and information security. At the same time, the results of the different authors bring valuable nuance and detail, adding to the overall picture of the impact of innovation on logistics systems.

Conclusions

This research highlights the transformative effect of digital innovation on contemporary logistics systems. The use of new technologies like robotic assembly systems, warehouse automation, IoT, blockchain, and artificial intelligence has changed traditional logistics methods, making global supply chains more efficient, accurate, and adaptable. These advances provide real-time cargo tracking, dynamic routing, and predictive inventory management, enhancing operational efficiency and promoting the environmental sustainability of logistics networks.

International comparisons reveal the diverse speed and extent of digitalisation. Countries including Germany, the United States, China, Japan, and South Korea exhibit advanced logistics systems supported by cohesive regulatory frameworks, investment in AI-driven technologies, and workforce retraining initiatives linked with Industry 4.0. Conversely, Turkey, Ukraine, and Azerbaijan, despite significant progress, confront structural obstacles pertaining to legislative fragmentation, cybersecurity preparedness, and the digital readiness of SMEs. Azerbaijan exhibits considerable potential, as indicated by heightened investment in transportation infrastructure, critical projects such as the Zangezur corridor (TRIPP), and a rising interest in digital freight technology.

The research underscores numerous significant obstacles linked to digital transformation. Included are cybersecurity vulnerabilities, data privacy hazards, ethical issues concerning algorithmic decision-making and biometric surveillance, and opposition to organisational change, particularly in family-owned or regionally entrenched enterprises. Furthermore, the labour ramifications of automation must not be disregarded. Automated systems are gradually replacing low-skilled positions, leading to an increasing need for expertise in data analytics, logistics software engineering, and cyber-risk management. Addressing these changes necessitates coordinated upskilling initiatives and inclusion policies to avert labour market polarisation.

The study provides specific recommendations based on the findings. Azerbaijan's policy initiatives should prioritise regulatory alignment with international standards, the establishment of cloud-based logistics platforms for SMEs, and the implementation of a national logistics upskilling programme. Companies should create a clear plan for using digital technology that includes assessing their needs, setting up cybersecurity measures, gradually introducing new platforms, and measuring success with performance metrics.

Future research should investigate digital transformation frameworks specifically designed for SMEs within varied regulatory and economic contexts. A thorough look at data ethics, the social effects of logistics automation, and how well international regulations work together will help understand the complexities of sustainable digitalisation in global logistics better.

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